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(71) Applicant: **SAMSUNG ELECTRONICS Co. Ltd.**
Kyungki-do, Seoul (KR)

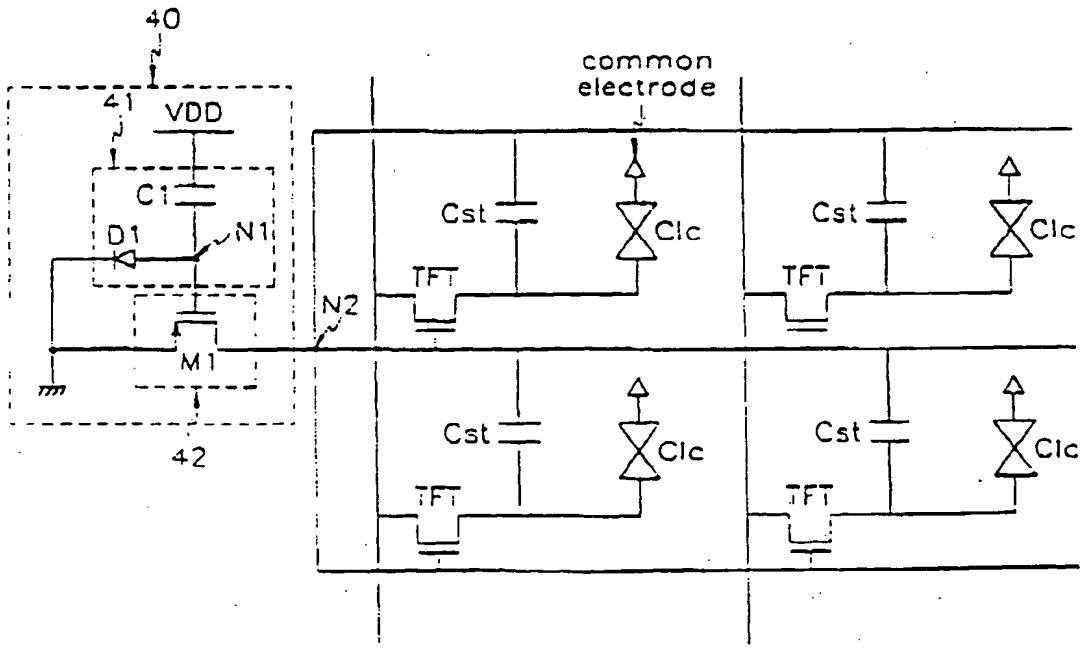
(72) Inventor: **Moon, Seung-Hwan**
seocho-ku, Seoul (KR)

(74) Representative: **Kensett, John Hinton**
Saunders & Dolleymore,
9 Rickmansworth Road
Watford, Hertfordshire WD1 7HE (GB)

(54) A screen clearing circuit, a liquid crystal display device having the same and a method of driving the same

(57) A screen clearing circuit for a thin film transistor liquid crystal display (TFT LCD) and a driving method of the circuit are disclosed. The screen clearing circuit comprises a capacitor (C1), a diode (D1), and a PMOS transistor (M1). The present invention provides a screen clearing circuit for a TFT LCD and a driving method of the circuit, by which a residual image problem arising when the external power is cut off can be solved so that a good quality display can be achieved.

FIG. 4



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Description

The present invention relates to a screen clearing circuit for a thin film transistor liquid crystal display (referred to as a TFT LCD hereinafter), TFT LCD device having the same and a method of driving the circuit. More specifically, it relates to such a circuit and method, by which a display screen is cleared when the external power applied to a liquid crystal display is cut off.

In the following, a prior art will be described in conjunction with the accompanying drawings, wherein FIG. 1 shows an equivalent circuit of the gate structure of the a typical prior art TFT LCD. FIG. 2 is a diagram of a current-voltage characteristic curve of a TFT of a TFT LCD; and FIG. 3 is a diagram which shows prior art driving voltage waveforms applied to gate electrodes for turning on/off TFTs of a TFT LCD.

Each dot of a pixel of a TFT LCD comprises basically a TFT (a Thin Film Transistor) and a liquid crystal capacitor Clc.

As shown in FIG. 1, when a TFT is turned on, a liquid crystal capacitor Clc receives the voltage applied to the source electrode of the TFT and shows contrast. As shown in FIG. 3, after desired voltage is supplied to a liquid crystal capacitor Clc, a TFT is turned off during one frame to prevent the charges in the liquid crystal capacitor Clc from leaking out through the TFT, so chat the contrast can be maintained. At that time, a support capacitor Cst is also charged like the liquid crystal capacitor Clc, and it supplies a charge to compensate a part of the charge which leaks out of the liquid crystal capacitor Clc when the thin film transistor is turned off. Accordingly, the capacitor Cst prevents excessive discharge of the liquid crystal capacitor Clc, thereby allows stable contrast during one frame. Generally, the support capacitor called as a storage capacitor in the art of TFT LCD. A typical current-voltage characteristic of a TFT is shown in FIG. 2. As shown in FIG. 2, when the voltage Von is applied to the gate electrode of a TFT, the current Ion flows to cause the voltage already applied to the source electrode to be applied to the liquid crystal capacitor Clc. On the other hand, when the voltage Voff is applied to the gate electrode, current is greatly restricted to a level Ioff so that the charges stored in the liquid crystal capacitor Clc is prevented from leaking out. Typically, the voltage von is over 20V and the voltage Voff is below -2V.

The above prior art, however, entails the following problems when the driving power is cut off after having driven a TFT LCD. That is, immediately before the driving power of a TFT LCD is cut off from the outside, the voltage Voff is being applied to the gate electrodes of most of the TFTs of a TFT LCD, and the voltage Voff has already been stored in the support capacitors Cst of a TFT LCD of a previous gate type. Therefore, since the voltage Voff will be supplied to the TFTs until the voltage of the support capacitors Cst is discharged, the display screen of a TFT LCD can not be turned off or cleared even after the driving power is cut off. Further, in order to discharge the support capacitors Cst, the TFTs must be controlled with a voltage other than Voff. But the support capacitors Cst maintain the voltage Voff to cause the TFTs to be in a latched state, so that the voltage of the support capacitors Cst can not be discharged easily. For that reason, the prior art gate structure of TFT LCD does not allow a display screen to be cleared quickly, even after the driving power is cut off, thereby showing a strange residual image. This phenomenon acts as a DC bias to the liquid crystal capacitor Clc to cause a residual image, to be displayed dirty, leaving the user with an unfavourable impression about the product quality.

It is therefore an object of the present invention to solve the above problem by providing a screen clearing circuit for a TFT LCD and a method of driving the circuit, by which the screen can be cleared when the external power is cut off.

In order to attain the object, the screen clearing circuit of the present invention comprises:

a capacitor one end of which is connected to an external power;
reference voltage setting means serially connected between said capacitor and ground for setting a reference voltage on a node between said capacitor and said reference voltage setting means according to said external power; and
switching means whose a first electrode is connected to the node, a second electrode is grounded, and a third electrode is connected to a support capacitor of a thin film transistor liquid crystal display for grounding said support capacitor according to said reference voltage.

In order to attain the above objects, the present invention also comprises the steps of:

detecting whether an external power is being supplied; and
discharging a support capacitor of said liquid crystal display device when said external power is not supplied.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 shows an equivalent circuit of the gate structure of a typical prior art TFT LCD;
FIG. 2 is a diagram of a current-voltage characteristic curve of a TFT of a TFT LCD;
FIG. 3 is a diagram which shows prior art driving voltage wave forms applied to gate electrodes for turning on/off TFTs of a TFT LCD;
FIG. 4 shows a screen clearing circuit according to an embodiment of the present invention;

FIG. 5 is a diagram which shows the voltage waveforms of VDD, N1 and N2 in screen clearing circuit operating according to an embodiment of the present invention: and

FIG. 6 shows thin film transistor liquid crystal display device having a screen clearing circuit according to an embodiment of the present invention.

The preferred embodiments of the present invention will be described below in detail in conjunction with the accompanying drawings.

FIG. 4 shows a screen clearing circuit 40 according to an embodiment of the present invention. As shown in FIG. 4, the screen clearing circuit 40 includes a capacitor C1, a diode D1 and a PMOS transistor. The screen clearing circuit 40 according to an embodiment of the present invention is inactive when the external power VDD is being applied, but operates to discharge the voltage of the support capacitor Cst when the external power VDD is cut off. In FIG. 4, the cathode of the diode D1 is grounded, and the anode is connected through a first node N1 to one end of the capacitor C1, the other end of which is connected to the external power VDD. The source electrode of the PMOS transistor M1 is grounded, and the drain electrode is connected to one end of the support capacitor Cst, the other end of which is connected to the gate electrode of a TFT of a TFT LCD. The gate electrode of the PMOS transistor M1 is connected to the first node N1.

When the external power VDD is being applied, the first node N1 becomes approximately the ground level voltage GND through the diode D1, and, at the same time, the capacitor C1 is charged with the following quantity of charge:

$$Q1 = C1 * (GND - VDD) \quad (1)$$

where, assuming VDD to be 5V, Q1 = C1 * (-5V).

When the external power VDD is cut off later, VDD becomes the ground level OV, and the following voltage level appears at the first node N1:

$$V1 = Q1/C1 + GND = -5V \quad (2)$$

When the voltage level of the first node N1 is 0V, that is, the voltage of the gate of PMOS transistor M1 is 0V, it satisfies the condition Vgs > Vth, in which the PMOS transistor M1 is turned off, thereby exerting no influence on the support capacitor Cst. But when the external power VDD is cut off, the first node N1 shows a level of -5V, which satisfies the condition Vgs < Vth, in which the PMOS transistor M1 is turned on, and the voltage of the support capacitor Cst, one end of which is connected to the drain of the PMOS transistor M1, is discharged through the source electrode of the PMOS transistor M1 to ground. Accordingly, the voltage level applied to the gate of a TFT is changed from Voff to the ground level GND, which causes the TFT to turn on, thereby providing a channel to discharge the voltage of the liquid crystal capacitor Clc. The discharge of the liquid crystal capacitor Clc causes the residual image to disappear. The capacitor C1 and the diode D1 constitute a power cutoff detecting circuit 41, which detects whether the external power is being supplied. The first node N1, i.e., a node connecting the two elements C1 and D1 shows a ground level 0V when the external power is being supplied, while it shows -5V, which is the opposite polarity of the power voltage of 5V when the external power is cut off.

PMOS transistor M1 serves to discharge the voltage of the support capacitor Cst when the external power VDD is cut off. When the external power is cut off, the support capacitor is grounded by the operation of the switching means 42, thereby clearing the screen. In this embodiment, the diode D1 is provided as reference voltage setting means which supplies a predetermined voltage to the gate electrode of the PMOS transistor (M1, 42). And a resistor also can be used as reference voltage setting means without floating the voltage of gate electrode of the transistor 42. In addition, a PMOS transistor M1 is used as switching means 42 , and the capacitor C1 and the diode D1 are used as reference voltage setting means 40 in this embodiment, but other means having the same functions can be used within the scope of this invention.

FIG. 6 shows thin film transistor liquid crystal display device having the screen clearing circuit. As shown in Fig. 6, a controller 30 receives image data 90 outputted from the computer system (Not shown in figures), and controls a gate driving circuit 10 and a source driving circuit 20. The gate driving circuit 10 supplies gate-on voltages to the thin film transistors 70 successively through the gate lines 1, 2, 3,...n, n+1. When the gate-on voltage is supplied to a gate line, the source driving circuit 20 supplies data voltage to each pixel electrode through data line 72, thereby the liquid crystal(not shown in figures) in the pixel is arranged according to the data voltage. In prior art, gate off voltages are supplied to the gate lines 71 except the gate line to which the gate-on voltage is supplied. Since the support capacitor 80 are connected to the gate line of the previous neighbouring pixel, the support capacitors are charged with the gate-off voltage Voff. In this invention, as shown in Fig.6, by connecting the second node N2 of the screen clearing circuit 40 to Voff electrode of the gate on/off generator 50, each support capacitor 80 is connected to the screen clearing circuit 40. When the external power Vdd is not supplied to the screen clearing circuit 40, the support capacitors which is charged with voltage Voff discharges the voltage thereof by the operation of the screen clearing circuit 40. In actual operation of LCD device, gate-off voltages are supplied to gate lines except one gate line having gate-on voltage. The screen clearing circuit of this invention is not only adapt-

ed to the support capacitor (storage capacitor) of previous gate type LCD device but also adapted to the other type of support capacitor. In addition, other switching method can be used to discharge the support capacitor within the scope of this invention. As shown above, according to an embodiment of the present invention, a screen clearing circuit for a TFT LCD and a driving method of the circuit are provided, by which a residual image problem arising when the external power is cut off is solved so that a display of good quality can be achieved.

The above effect of the present invention can be used in display devices for notebook computers, and so on.

Claims

1. A screen clearing circuit for a thin film transistor liquid crystal display device, comprising:

   a capacitor one end of which is connected to an external power supply;
   reference voltage setting means serially connected between said capacitor and ground for setting a reference voltage on a node between said capacitor and said reference voltage setting means according to said external power; and
   switching means having a first electrode connected to the node, a second electrode which is grounded, and a third electrode which is connected to a support capacitor of a thin film transistor liquid crystal display for grounding said support capacitor according to said reference voltage.

2. A screen clearing circuit as claimed in Claim 1, wherein said reference voltage setting means is a diode.

3. A screen clearing circuit as claimed in Claim 1 or Claim 2, wherein said switching means is a PMOS transistor.

4. A screen clearing circuit as claimed in Claim 2, wherein said capacitor and said diode detects whether the external power is being supplied.

5. In a liquid crystal display device including a liquid crystal capacitor, a first switching means and a support capacitor, the improvement comprising:

   a second switching means having a first electrode connected to an external power electrode via a capacitor and grounded via reference voltage setting means; a second electrode which is grounded; and a third electrode which is connected to said support capacitor for grounding said support capacitor when said external power is not supplied.

6. A liquid crystal display device as claimed in Claim 5, wherein said second switching means is a PMOS transistor.

7. A liquid crystal display device as claimed in Claim 6, wherein said reference voltage setting means is connected to a gate electrode of said PMOS transistor, and comprises a diode or a resistor.

8. A liquid crystal display device as claimed in any of Claims 5. 6 or 7, wherein said support capacitor is connected to a gate line of a neighbouring pixel.

9. A method of driving a screen clearing circuit for a thin film transistor liquid crystal display device comprising the steps of:

   detecting whether an external power is being supplied; and
   discharging a support capacitor of said liquid crystal display device when said external power is not supplied.

FIG. 1(Prior Art)

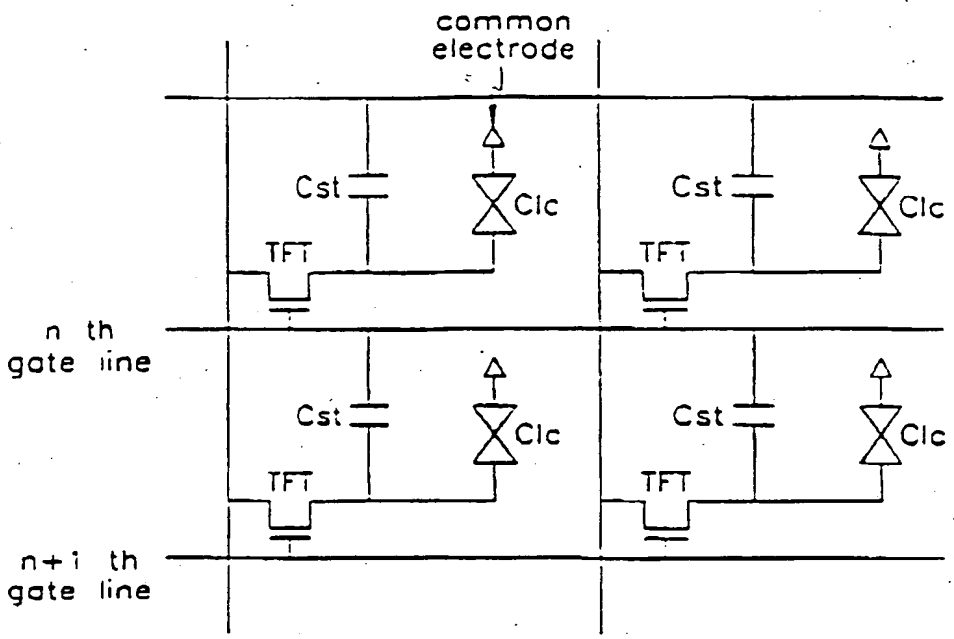


FIG. 2(Prior Art)

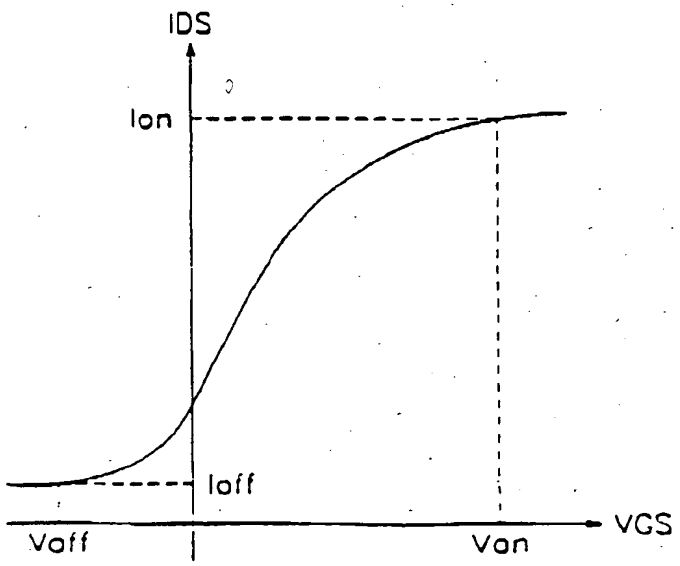


FIG. 3

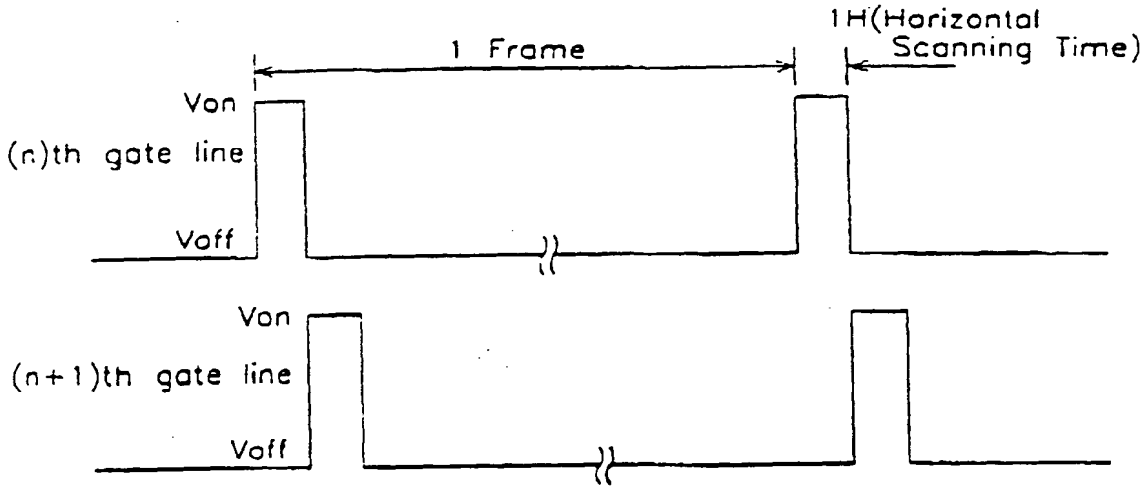

1 Frame
1H(Horizontal Scanning Time)
Von
(n)th gate line
Voff
Von
(n+1)th gate line
Voff

FIG. 4

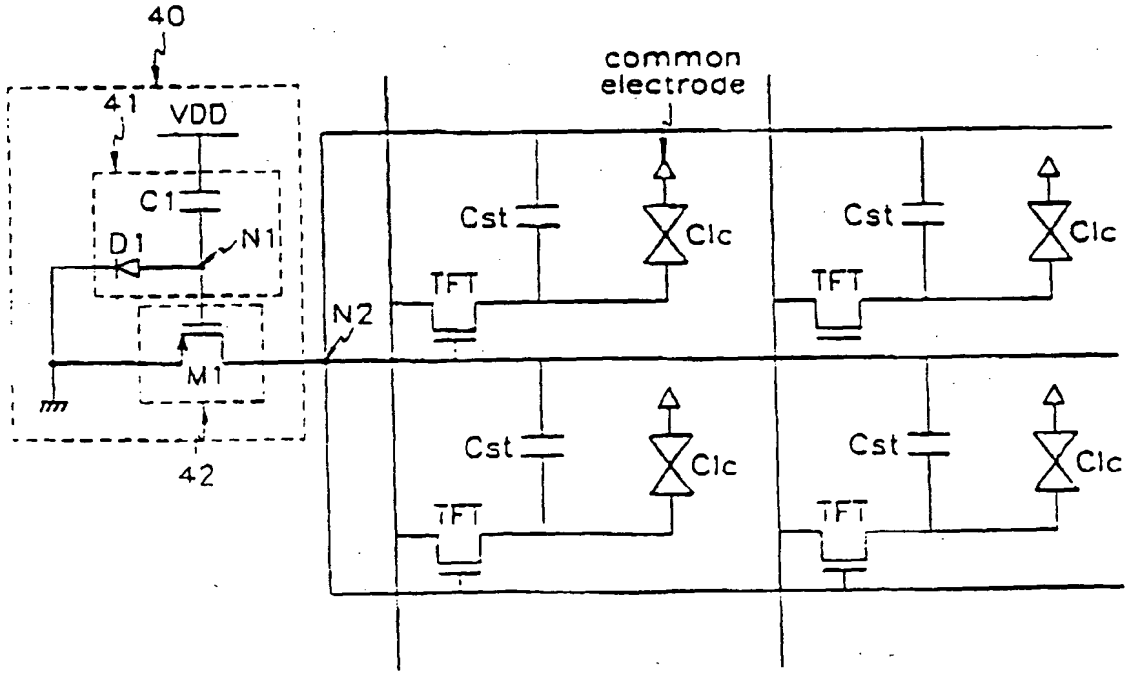
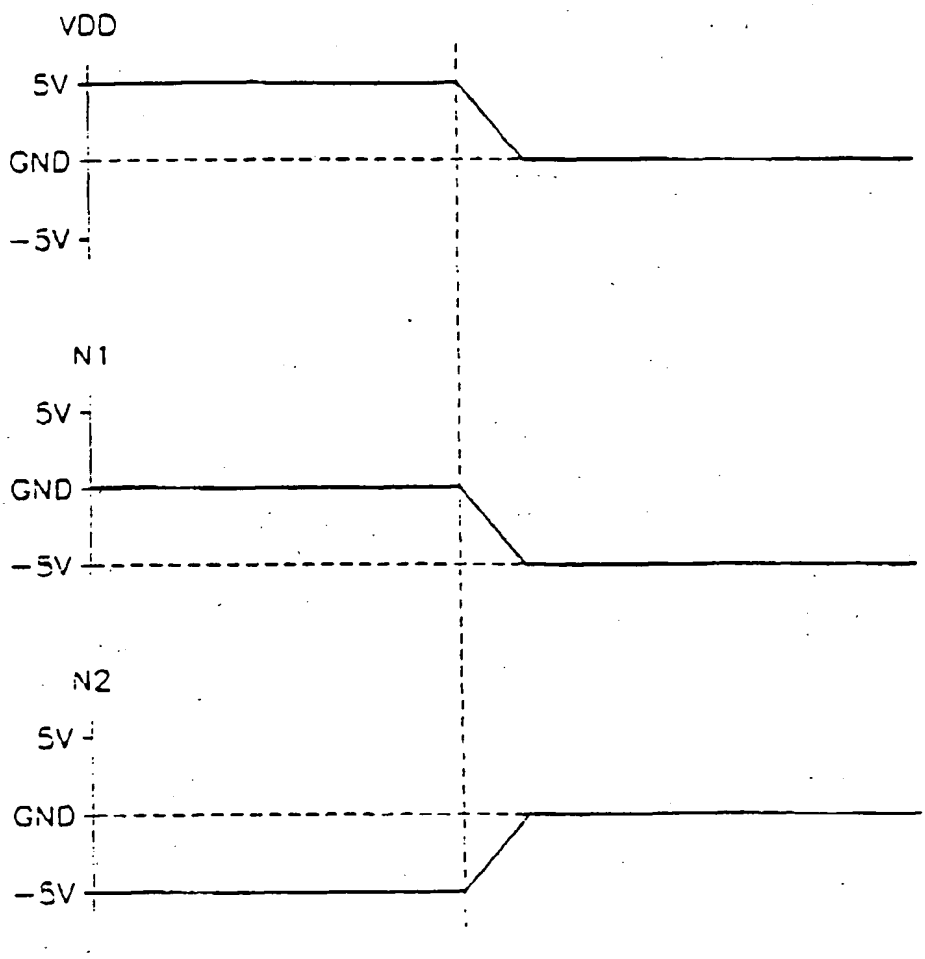

40
41
VDD
C1
D1
N1
M1
N2
42
common electrode
Cst
Clc
TFT

FIG.5



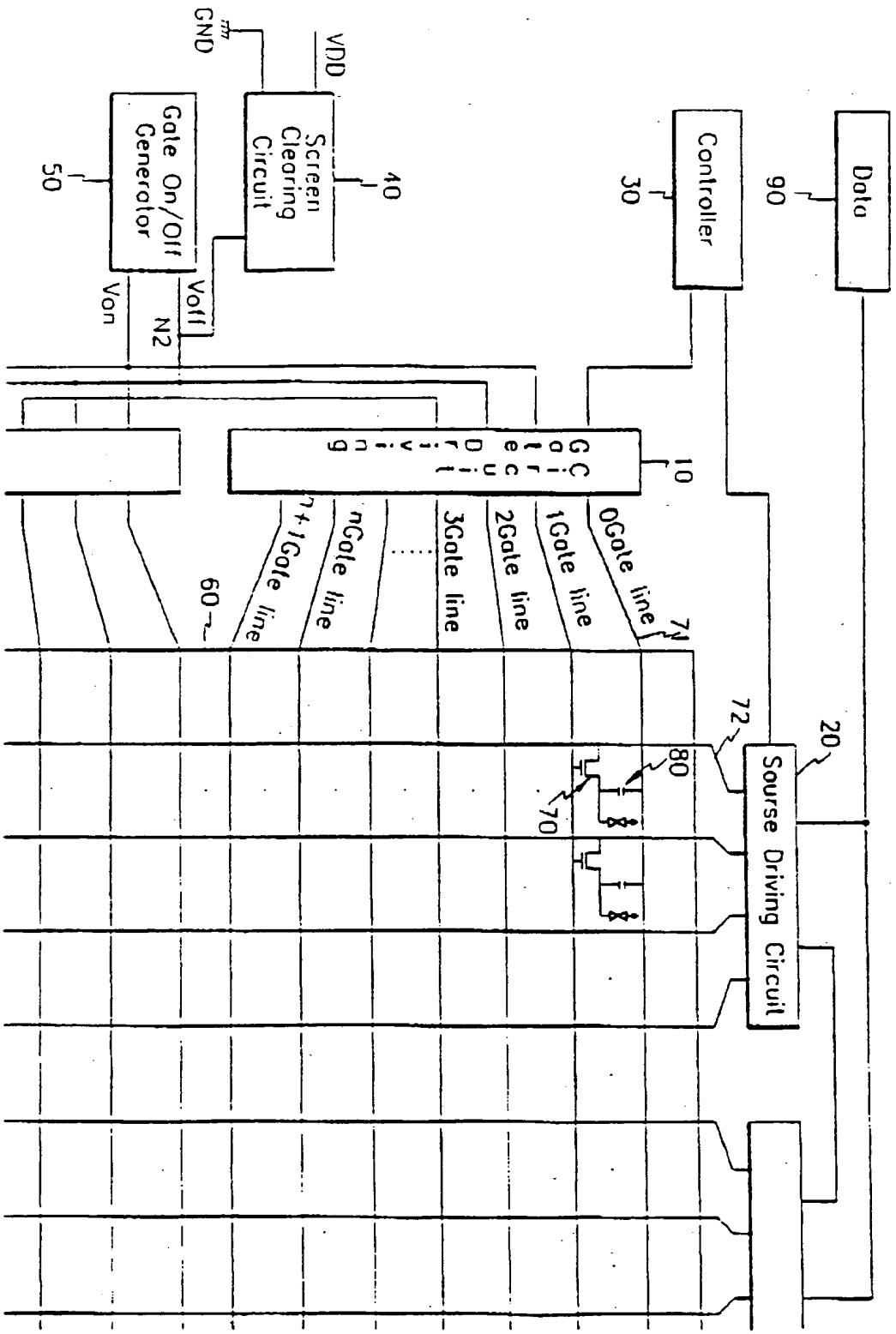

GND
VDD
Screen Clearing Circuit
40
Gate On/Off Generator
50
Von
Voff
N2
Controller
30
Data
90
Gate Driving Circuit
10
0Gate line
1Gate line
2Gate line
3Gate line
nGate line
n+1Gate line
60
70
80
72
20
Sourse Driving Circuit

FIG.6

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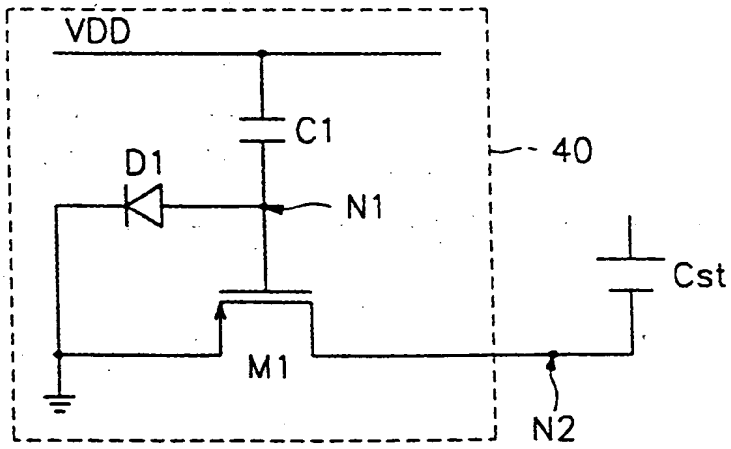
FIG.4



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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 6402

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP 0 364 590 A (HOSIDEN ELECTRONICS CO) 25 April 1990	1,5	G09G3/36
Y	* page 5, line 7 - line 26 *	9	
Y	EP 0 605 846 A (SONY CORP) 13 July 1994 * column 2, line 10 - line 14 * * column 8, line 20 - line 37 *	9	
A	US 5 430 460 A (TAKABATAKE MASARU ET AL) 4 July 1995 * figure 6A *	8	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G09G
G06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	4 March 1997	Amian, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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